

## Muscle Fibres

Muscles are composed of thousands of individual muscle fibres, which are held together by connective tissue. However, muscle fibres may differ in physiological makeup.

Skeletal muscle has two main fibre types: **slow twitch** and **fast twitch**. Fast twitch and slow twitch fibres vary in different muscles and in different individuals – these proportions tend to be genetically determined. As the fibres have distinct characteristics, this will affect performance in certain sporting activities.

For example, a marathon runner may have almost 80% slow twitch fibres which are designed for long periods of low intensity work; whereas, a sprinter may have 80% fast twitch fibres, which can generate extremely large forces, but fatigue easily.

Each muscle contains both types of fibres, but not in equal proportions. The fibres are grouped in **motor units**, with only one type of fibre in any given unit.

- Slow twitch (or **Type 1**) fibres are referred to as **slow oxidative** (S.O.). They are red in colour, contract slowly, are aerobic (supplied with oxygen), are used in endurance based activities because they can contract repeatedly, but they exert less force.

These are slow twitch fibres because they contract more slowly than type II (fast twitch) fibres. The myelin sheath of the motor neurone stimulating the muscle fibre is not as thick as that of the fast twitch unit, and this reduces the amount of insulation, slowing down the nerve impulse. Slow twitch fibres do not produce as much force as fast twitch fibres, but can easily cope with prolonged bouts of exercise. They are more suited to aerobic work as they contain more **mitochondria** and **myoglobin** (see lesson 10) and have more blood capillaries than fast twitch fibres. Slow twitch fibres have the enzymes necessary for **aerobic respiration** and are able to break down fat and carbohydrates to carbon dioxide and water. This is a slower process than releasing energy anaerobically, but it does not produce any fatiguing by-products.

- Fast twitch (or **Type 2**) fibres are white in colour, contract rapidly, are anaerobic in nature (no oxygen supply), are used for strength/speed based activities because they can exert great forces, but they are easily exhausted.

Fast twitch fibres are further divided into **Type 2a** and **Type 2b**.

- **Type 2a** fibres are referred to as **fast oxidative glycolytic** (F.O.G.). These fibres take on certain type 1 characteristics through endurance training. They therefore tend to have a greater resistance to fatigue, and are used in activities which are fairly high in intensity and of relatively short duration.

The motor neurone stimulating the type IIa fibre has a thicker myelin sheath than the slow twitch fibres, so it can, therefore, contract more quickly and exert more force. The amount of force produced by these fibres is greater than slow twitch ones because there are more muscle fibres in each motor unit. They can produce energy both aerobically and anaerobically by breaking down carbohydrates to pyruvic acid (see lesson 11), but it is more suited to anaerobic respiration, allowing it to release energy very quickly. The rapid build up of lactic acid (a by-product of anaerobic respiration) lowers the Ph (due to increased acidity) and has a negative affect on enzyme action, causing the muscle fibre to fatigue quickly.

- **Type 2b** are pure fast twitch fibres and are referred to as **fast twitch glycolytic (F.T.G.)**. These are used for activities of very high intensity and have a much stronger force of contraction. This is because the motor neuron that carries the impulse is much larger. There are generally more fibres within a fast twitch motor unit, and the muscle fibres themselves are larger and thicker.

The motor neurones supplying this fibre type are large, and this increases the speed of contraction. The neurone also activates a greater number of muscle fibres allowing each motor unit to produce a far greater force than slow twitch fibres. These fibres are very quick to contract, and can exert a large amount of force. They rely heavily on anaerobic respiration for releasing energy as they have very few mitochondria. Energy is, therefore, released rapidly, but the muscle fibre is also quick to fatigue.

Characteristics	Slow Oxidative	Fast oxidative glycolytic (F.O.G.)	Fast twitch glycolytic (F.T.G.)
Fibres per motor neurone	10-180	300-800	300-800
Motor neurone size	Small	Large	Large
Speed of contraction (ms)	Slow (110)	Fast (50)	Fast (50)
Force of contraction	Low	High	High
Size	Smaller	Large	Large
Fatigue resistance	Fatigue resistant	Less resistant	Easily fatigued
Aerobic capacity	High	Medium	Low
Capillary density	High	High	Low
Mitochondrial density	High	Lower	Low
Myoglobin content	High	Lower	Low
Anaerobic capacity	Low	High	Very high
Sarcoplasmic reticulum development	Low	High	High
Type of myosin AT Pase	Slow	Fast	Fast

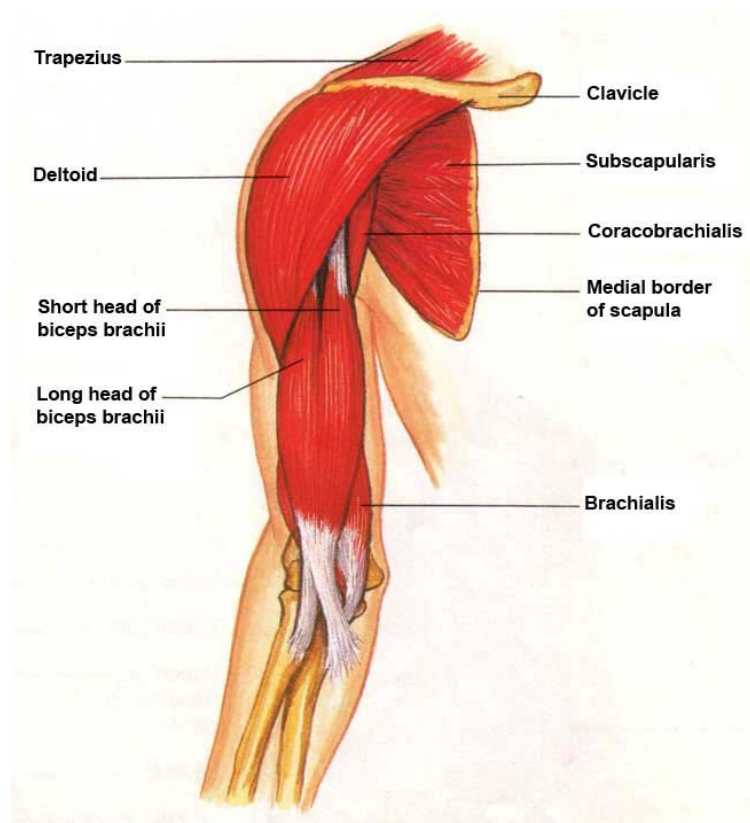
## Connective Tissues

Connective tissue is responsible for holding all the individual muscle fibres together. It surrounds individual muscle fibres and encases the whole muscle, forming tendons at the ends. Tendons attach muscle to bone and transmit the 'pull' of the muscle to the bones, causing movement and harnessing the power of muscle contractions. Tendons vary in length and are composed of parallel fibres of collagen. They attach directly onto the periosteum of bones through a tough tissue known as **Sharpey's fibres**.

The ends of the muscle are referred to as the **origin** and the **insertion**. The origin is the more fixed, stable end, and is attached to a stable bone against which the muscle can pull. This is usually the nearest **flat bone**. The insertion is the muscle attachment on the bone that the muscle moves.

A useful analogy is to nail an elastic band to a wall. Where it is fixed into place is termed the origin. When holding the other end of the band and pulling; where it is being held is termed the insertion.

The muscle belly is the thick portion of muscle tissue sited between the origin and insertion. A muscle can have more than one origin, while maintaining a common insertion. For example, biceps means two (bi-) heads (-ceps), and triceps means three (tri-) heads (-ceps). The biceps has two origins or heads located on the scapula, which pull on one insertion in the radius, raising the lower arm when contraction occurs.



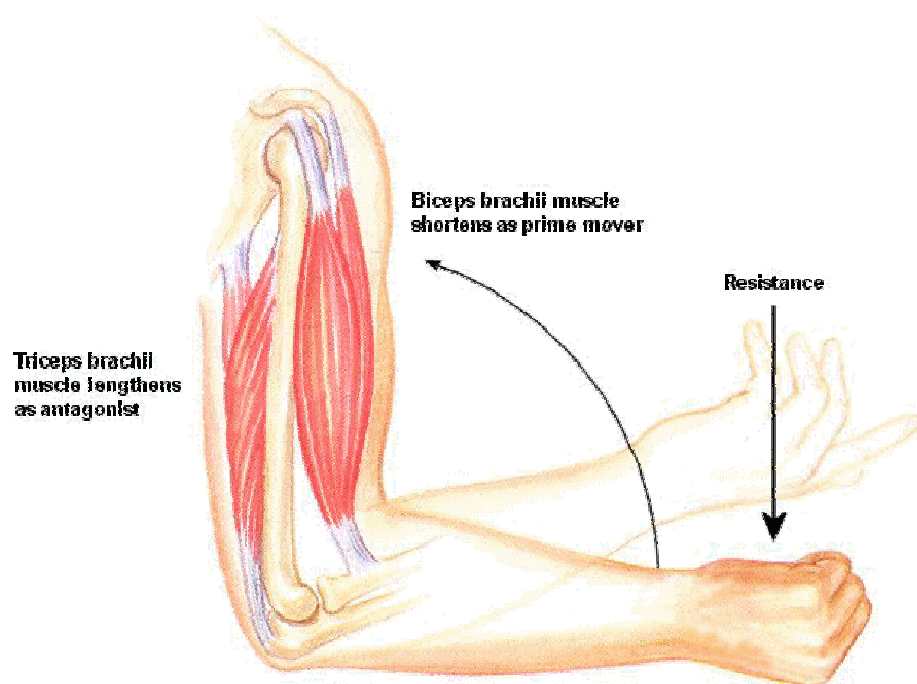
When a muscle contracts it shortens and the insertion moves closer to the origin, creating a movement at a joint.

### Antagonistic Muscle Action

Muscles never work alone. In order for coordinated movement to take place, the muscles must work as a group or team, with several muscles working at any one time.

The muscle directly responsible for initiating the desired joint movement is called the **agonist** or **prime mover**. A muscle whose action is opposite to that of the agonist is known as the **antagonist**.

For example, flexing (bending) the arm at the elbow. The muscle responsible for this action is the biceps brachii, and it is therefore the agonist. Whilst the bicep shortens in order to pull on the radius and raise the lower arm, the triceps brachii (back of the arms) must lengthen in order for this action to take place. The triceps in this instance act as the antagonist.



The muscles work as a unit, requiring a high degree of coordination. This coordination is achieved by nervous control. When the prime mover is being stimulated, the nerve impulse to the antagonist is inhibited – this is known as **reciprocal inhibition**.

**Fixator** muscles are stabilizers which also work in the movement. Their role is to stabilise the origin so that the agonist can achieve maximum and effective contraction. The fixator muscle increases in tension but does not allow any movement to take place. In the above example, the trapezius muscle (upper back) contracts to stabilise the scapula to create a rigid platform.